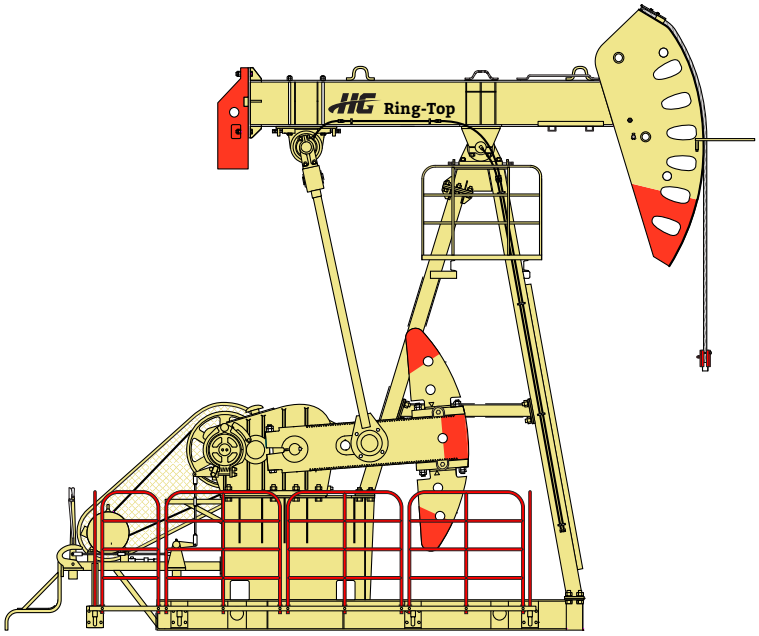
H160-173-86

Pump Unit

Owner's Manual

Install – Operate – Adjust – Maintain



Hybrid crank and beam balance pump unit.

WARNING

Read this manual closely for advice on avoiding serious injury to personnel, damage to equipment, and risks to property.

Tianjin Ring-Top Petroleum Manufacturing Co., Ltd.

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1 About our Company

Tianjin Ring-Top Petroleum Manufacturing Co., Ltd. is a privately owned company with independent import and export rights in China. We have highly motivated staff with very capable engineers and skilled trades. Our well-equipped 60,000 Square meters of workshop space allows us to rapidly meet demand for artificial lift units. Our design capabilities include a wide range of types and sizes to meet practically any need for efficient, reliable, cost effective beam pumps. Other products we supply to the oil field industry include drill pipe, drill couplings, casing, tubing, and innovative drill bits. We have had a certified ISO 9001-2000 quality management system since 2002, as well as various API certifications since 2006.

We continually refine and develop walking beam pump designs to meet the specific needs of our customers. Custom orders for pumps with client specified design features are welcomed. In addition to conventional crank and beam balance designs, product variations include motorized adjustment of beam balanced units, double horsehead units, concrete beam balance weights, and custom structural steel options. Further innovations by our company are equipment such as the SB serial sand pump, automated control equipment, and robust gear reducers from 40D to 912D.

Tianjin Ring-Top provided pump units to the China National Petroleum Corporation for use the Yanchang Oilfield, Daqing Oilfield, and Huabei Branch. Another major customer is Sinopec in the Northern China Oilfield. Our products are known for quality, after sales service, and power efficiency. Energy efficient pump units have been exported to, and are becoming increasingly popular in North America, the Middle East, West Asia, and North Africa markets.

We enjoy a long history of manufacturing pump units, with solid technique and a thorough quality management system. We also have a qualified team for after sales service. Our consistent objective is to provide products which are safe, reliable, easy-to operate, and energy efficient. We adhere to the principle of quality first. Meanwhile, we persist in providing appropriate and satisfactory products and service to our end users. Our walking beam pump units are manufactured in adherence ISO 9001-2000, API Specifications 11E and Q1, plus China Standard SY/T5044-2003. Our manufacturing license in China is XK14-003-00039.

We take pride in performance qualities as well as attention to the image and detailing of our products and company. Not only is our design and production management team highly skilled and capable, but we cheerfully provide genuine service to our customers.

API Specification Q1 (Quality Management System)
API Specification 11E (Pumping Units)
License Number 11E-0080

2 Letter to Users

Thank you for purchasing our pump unit. As you read this manual and use our products, we invite you to become our friend. We welcome visits to our headquarters, manufacturing plant, and test facilities in Tianjin, China.

Please pay close attention to ***Safety Rules*** covered in this manual. Additional safety measures will be required by related Federal, State, and Local government agencies. Further, your company will also have safety policies and procedures for you to follow.

We have developed a robust and energy efficient walking beam pump unit which is a hybrid crank and beam balance design. For a wellhead that requires artificial lift, our pump unit provides an appropriate long stroke, low frequency, and high energy efficiency. Further, high reliability and high maintainability make our pumps a wise investment. This series is suitable for pumping crude oil of moderate and low viscosity, including high water-content fluids.

This pump unit manual supplies data on the structure, performance, installation, safety procedures, lubrication schedule, maintenance, and adjustment. Please closely review and follow this manual. You may make appropriate changes according to the particular condition of the oilfield and your internal operational standards.

We wish you every success in your oil pumping endeavors. Hopefully you will feel our presence as you work with the walking beam pumps we took pride in producing. Please fill the information feedback card and return to us along with your valued suggestions for a timely response.

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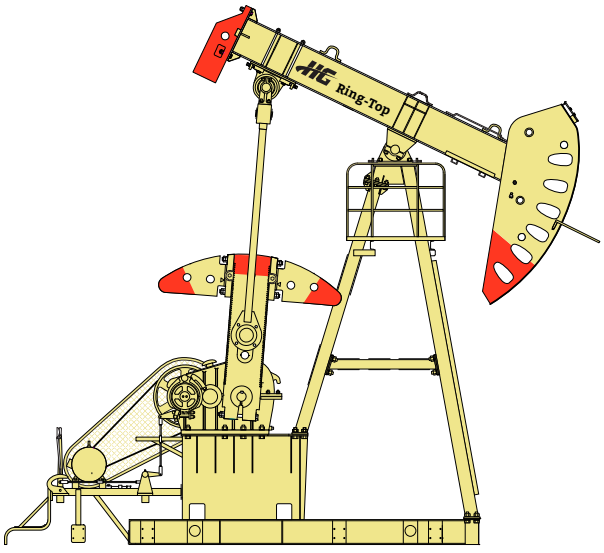
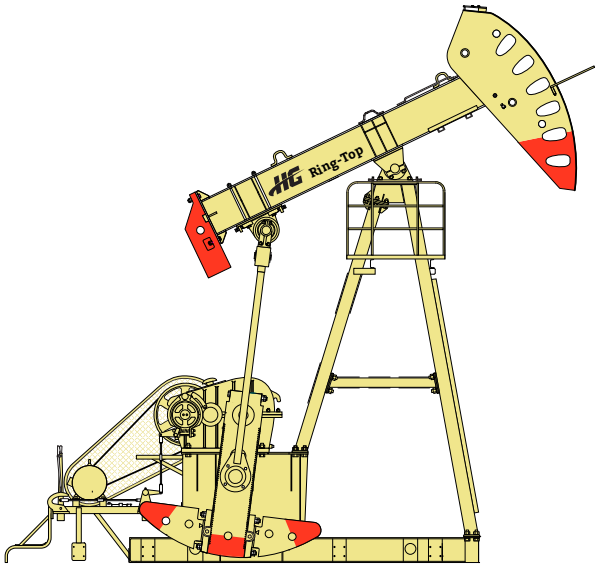




3 Safety Rules

Walking beam pumps have large moving parts under heavy stress, making them dangerous to operators and any others that may come near. For safe use, installers and operators must have a high level of skill, knowledge, and experience. Fencing and guards must be specified and installed appropriate to the possible proximity of people and animals. Please contact us for suggestions on training and educational programs available to the industry.

ATTENTION: For safe and successful operation, the contents of this manual must be studied carefully. You will find safety notices and technical notes throughout. Some of the key points are:

3-1 Ensure that personnel are properly equipped for this dangerous work. Plan and prepare for safe operations. Keep everyone away from activated components. For any continuous operation, check that all guards are in place.

3-2 Cut off power to/from the motor/engine before braking. Brake slowly to stop the unit in the position desired. After stopping the unit, the crank still has the potential to rotate.

3-3 After braking, set the brake stop pawl. For work where crank movement could lead to danger, chain the brake drum and otherwise secure the pump against rotation and movement.

3-4 Before starting the motor, remove any securing chains, disengage the brake stop pawl, and finally release the brake shoes with the brake handle.

3-5 Electric components and the electric power lines should be protected, preventing damage from exposure to sun and weather. Ensure proper electrical grounds.

3-6 When adjusting the position of balance weights, set the crank in a horizontal position slightly tilted in direction of adjustment. Afterwards, properly torque bolts and install safety cog.

3-7 When adjusting the stroke, carefully review the technical and safety instructions for this challenging operation in Subsection 9-1 “Adjust Pump Stroke.”

3-8 When mounting the horsehead, ensure that both safety pins are installed properly and secured with new cotter pins. Also firmly tighten adjusting bolts.

3-9 Prepare fire fighting apparatus and resources to be used in case of fire from the prime mover, well head, etc. Also have first aid kits, training, and resources for other accidents.

3-10 Be mindful of the remote location of typical pump units and plan accordingly for possible accidents and breakdowns (including transportation vehicles).

3-11 Closely follow regular maintenance, adjustment, and lubrication schedules. Remove loose objects which can affect safety and smooth operation.

3-12 Wear appropriate PPE (personal protective equipment) and close fitting non-synthetic clothing. Jewelry, neckties, and lanyards can also present risks. PPE includes safety glasses with side shields, hard hats, gloves, and steel-toed shoes/boots.

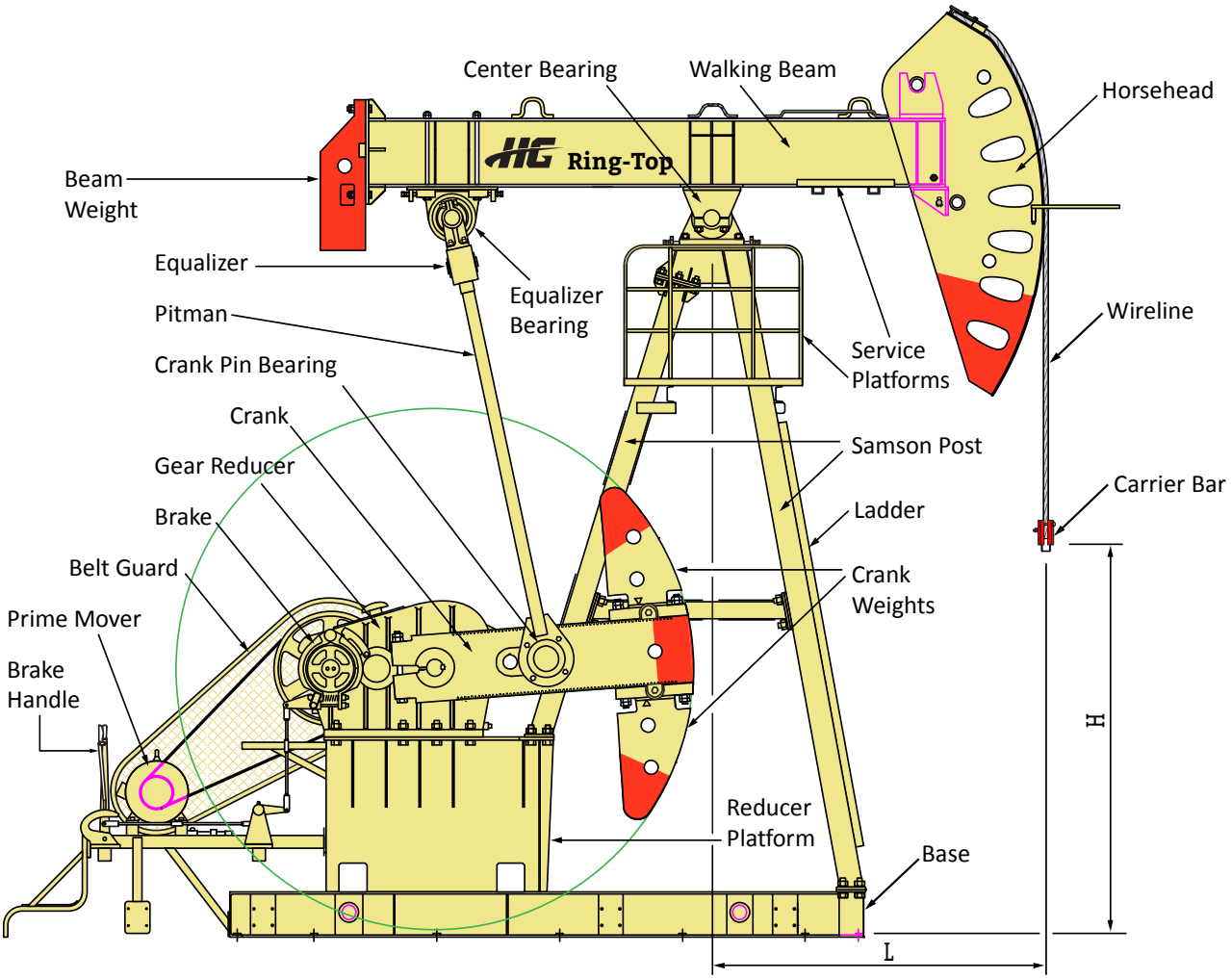
4 Specifications

Model H160-173-86	
Polished Rod Capacity (pounds), diameter	17,300 lbs
Stroke Lengths for the 3 different crank bores (inches)	55” 66” 86”
Wireline and polished rod diameters (inches)	1” and 1.5”
Typical stroke Frequency options (strokes per minute, with 970 rpm prime mover)	6.4, 9.6, 11.7
Maximum Counter Balance Moment (pound-inches)	172,000 lb-ins
Overall Dimensions (inches)	300” × 252” × 108”
Total Pump Unit Weight (pounds, excluding motor, but including belt guard and crank guards)	29,365 lbs
Balance Weights	
Beam Balance Weight (pounds)	2,205 lbs
Crank Balance Weight (pounds)	1,340 lbs × 4 (5,360 lbs total)
Weight of Cranks (pounds)/Center of Gravity (inches)	756 lbs x 2 / 27.8”
Crank Pin Weight (each, pounds)	27.6 lbs
Structure Unbalance—downward force at wireline to keep beam level, w/o pitmans connected to cranks	1,450 lbs
Distance from reducer output shaft center to centers of crank pin bores (inches/mm)	21.26” 26.98” 31.49” 540 mm, 660 mm, 800 mm
Reducer	
Gear type	Involute, Double Reduction
Maximum Torque Rating (pound-inches)	160,000 lb-ins
Overall Gear Ratio	28.506
Belt Sheave Diameter (inches/mm)	31.9” / 810 mm
Input/Output Shafts, center-to-center (inches/mm)	29.53” / 750 mm
Gear Reducer Weight (pounds)	5,584 lbs
Motor	
Rated Power (Hp/kW)	24.8 Hp / 18.5 kW
Speed (revolutions per minute)	970
Number of V-belts (C-type) and length (inches/mm)	2 V-belts, 177” / 4,500 mm
Motor Sheave diameter options (inches)	6” 9” 11”

On this pump unit, conventional crank balance weights are used together with a beam balance weight. This mid-range size pump combines the advantages of the two balance types for a very efficient and reliable pump unit. Variations of this design include gear reducers rated at 114, 160, and 228 thousand pound-inches.

An optional feature (not part of this design) is the use of a phase angle between the crank pin center line and the centerline of the crank weights. This causes movement of the crank shaft out of phase with the torque produced by load, creating a flatter net torque curve (reducing the peak reducer torque). Somewhat less energy is consumed and component life is increased by the use of phased cranks. Some of the advantages of a phased crank can also be obtained with the practice of staggering the position of crank weights on the crank arm.

5 Structure Summary



Beam Pump Unit Structure

The walking beam, horsehead, samson post, equalizer, pitmans, reducer platform, and base are formed from welded steel plate with a Q235B Chinese specification. For cold applications below 5°F, Q345B (0.16% C, 1.2 to 1.6% Mn) specification steel can be supplied.

5-1 Horsehead, Wireline and Carrier Bar

The top of the horsehead has a semi-circular seat to loop the wireline (wire rope) over. There is a steel terminal/lug fixed on each end of the wireline. The carrier bar rests on the terminals. A polished rod is passed through the carrier bar, with a polished rod clamp installed above the carrier bar.

A bolted cover plate at the top of horse-head prevents the wireline from coming off. The horsehead connects to the walking beam with two horizontal shafts, the upper shaft engaging a notched support on the walking beam, and the lower shaft pivoting against the end of the walking beam. Safety pins and adjustment bolts secure the horsehead in position on the walking beam.

5-2 Beam, Beam Weight, and Center Bearing

At the end of the beam opposite the horsehead, the beam balance weight is attached. Midway along the walking beam, the center bearing assembly is bolted on. The center bearing is attached to the top of samson post. The center bearing assembly has two sets of roller bearings. The center bearings are properly filled with lubricating grease at our factory.

5-3 Base, Reducer Platform, and Samson Post

The base is supplied with the reducer platform attached (welded). The prime mover (electric motor) mounting structure is supplied separately, to be attached by the user.

The samson post has two front legs and one rear leg (double beam) as part of the truss structure. The samson post is fixed to the base by screw bolts, the front legs connected to the pump unit base, and the rear leg connected to the reducer platform.

5-4 Ladder and Service Platforms

A service platform is installed at the top of samson post. A ladder is positioned between the front legs of samson post to provide operator access to the platform. Another service platform is attached to the beam for worker access to the horsehead—safety harness attachment points are included.

5-5 Gear Reducer, Cranks, and Crank Pins

A double-reduction gear reducer is fixed to the reducer platform of the base by screw bolts. The output shaft is toward the wellhead, and the input shaft is away from wellhead. Cranks are fixed to the shaft prior to shipping. A V-belt sheave is attached to one end of the input shaft and a brake drum is attached to the other. The reducer gears and shafts are lubricated with premium extreme pressure gear oil. The reducer is shipped without gear oil, so be certain to properly fill before applying torque from the motor. To confirm proper gear oil level, the reducer has a view port conveniently visible from the rear of the pump (opposite the wellhead).

When facing the pump unit with the well on the right, the preferred direction of revolution of the reducer output shaft is clockwise. In the event of severe wear on reducer gear teeth, the life of the reducer might be extended by reversing rotation.

Crank pins are attached to the desired crank bores at our factory before shipment. Pre-lubricated self-aligning roller bearings are connected to the crank-pins for attaching the pitmans. For connection to the crank, one crank pin has left-hand threads, and the other right-hand threads.

5-6 Crank Weights

Crank weights are attached to the cranks with ”T” bolts and a set cog. There are integral gear tracks on the cranks, which can be used to adjust the position of crank weights for obtain optimum balance. The cranks also have permanently cast distance marks to indicate the position of crank weights.

5-7 Electric Motor and Belt Cover

Shown here is the use of an electric motor as the prime mover. Proper V-belt tension and alignment is established when the motor is installed. We recommend API TR 11L6 ***"Technical Report on Electric Motor Prime Mover for Beam Pumping Unit Service"*** as a guide on specifying and procuring motors.

5-8 Brake and Brake Handle

The brake actuation assembly is composed of a set of rigid rods and pivots. One end of the actuation assembly is linked to the brake handle, the other is fit onto brake shoes which engage the brake drum attached to the reducer input shaft. The brake handle is positioned at the back of base for convenient access. The brake is intended to stop of the unit during pump installation, pump maintenance, and well service. After braking the pump unit to a stop, secure the brake handle and then swing the pivoting brake stop pawl into the notched brake drum flange.

5-9 Pitmans, Equalizer, and Equalizer Bearing

The two pitmans connect the cranks to the equalizer, one end of each pitman to the crank pins and the other end to the equalizer. The pins which connect the pitmans to the equalizer allow enough movement to balance the forces on the equalizer bearing.

The middle of the equalizer is bolted to the equalizer bearing assembly .The equalizer bearing is a self-aligning bearing. The equalizer bearing assembly is attached to the bottom of the walking beam, near the beam balance weight. The bearing is properly filled with lubricating grease at our factory.

6 Assembly and Installation

WARNING: Installation, adjustment, and operation of a walking beam pump involve dangerous equipment, flammable oil well products, and remote locations. This combination of factors requires a high level of attention to safety.

During installation and service work, proper PPE (personal protective equipment) must be used by workers. These include eye protection, hard hats, steel toed boots/shoes, and work gloves. Clothing should be close fitting and exclude neckties, lanyards, and jewelry. Clothing should also be non-synthetic (e.g. cotton and wool) to reduce flammability while working around petroleum products.

While good PPE helps reduce some risks, the positioning of heavy loads and pump movement (e.g. rotation and up/down) still present serious risks of injury and death. Work teams require adequate training, experience, and planning to perform the following tasks safely. This Owner's Manual will alert you to many dangers, so review it carefully.

As always, ensure that local, state, and federal safety regulations are observed. Further, your company's safety and technical standards may apply to the use of this beam pump.

6-1 Bolt Torques

During assembly of the pump unit, ensure that all connections are clean and free of debris. For some surfaces, it will be necessary to check and clean while they are elevated and properly supported. The following table lists torque values for properly tightening bolts on the pump unit. Diameter values refer to outer thread dimensions:

Diameter of screw bolt	16 mm	20 mm	24 mm	27 mm	30 mm	36 mm	42 mm
pound-inches	690	1,380	2,424	3,584	4,769	8,407	14,389
kN-meters	78	156	274	405	539	950	1,626

Jam nuts (locking nuts) are not installed as tight as specified above. Full size jam nuts should be torqued to about 1/2 to 2/3 of the values listed. Reduced height jam nuts should be torqued to about 1/4 to 1/3 of the values listed. Alternately, hand tighten the jam nut until there is no up and down play, and then tighten 1/2 or 1/4 turn more.

6-2 Attach Base to Foundation

The pump unit foundation can be of two different types: a single monolithic concrete foundation, or a multipart prefabricated concrete foundation. A monolithic foundation is poured in place at a well site. A multipart prefabricated foundation includes multiple blocks with slots for positioning anchor bolts. With either type of foundation, the soil on the site must first be properly leveled and compacted. The foundation and bolt attachment design for any given installation will vary depending on soil conditions, strength of concrete used, polished rod load, and established user practices. Please contact us to discuss the details of foundation design for your installation.

One important guide you should review and apply is API's RP 11G ***"Recommended Practice for Installation and Lubrication of Pumping Units."*** This manual reflects information in that publication, but study of RP 11G will give you a more thorough understanding of best industry practices.

WARNING: Do not stand under any elevated loads, such as the pump unit base. This is important whether moving or stationary, lifting by crane or forklift.

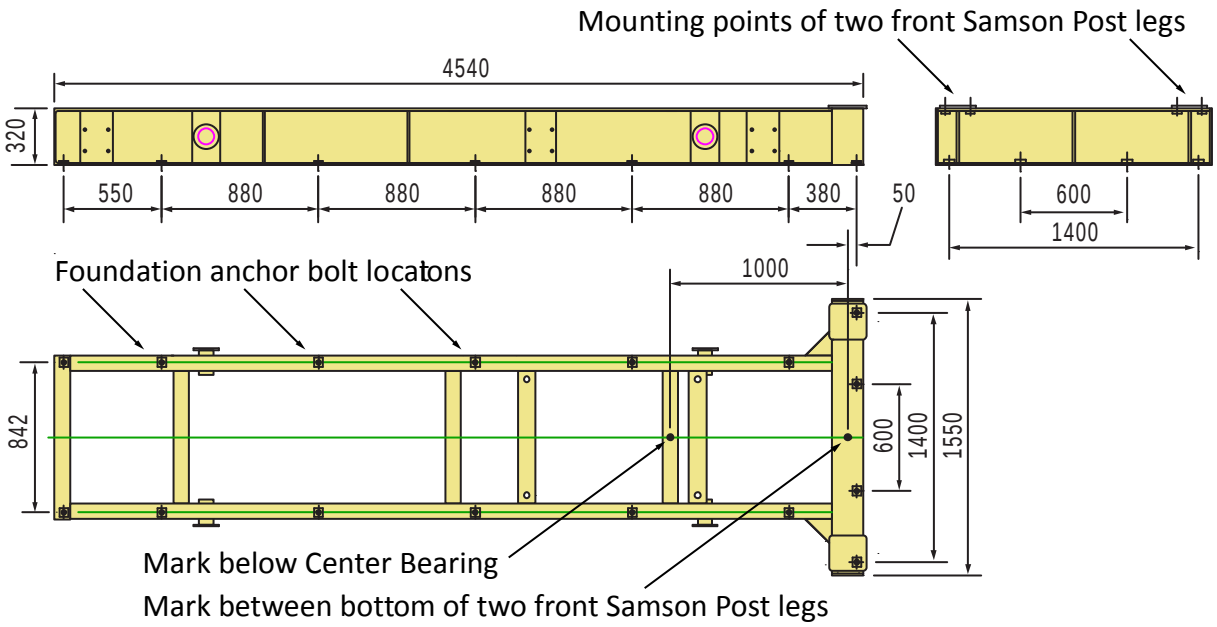
The best orientation of the pump is with the horsehead pointing in the opposite direction of prevailing winds. Approaching the pump is best done from the rear, and if well releases are occurring, the rear will be the least affected.

The height of the top face of the foundation is determined to give adequate clearance between the top of the well-head Christmas tree and the lowest position of the Carrier bar. The lowest height **H** from Carrier bar to the top face of foundation, and the distance **L** from the center of samson post to the wellhead are given in the following table (refer to the above "Beam Pump Unit Structure" diagram for **L** and **H** measuring points).

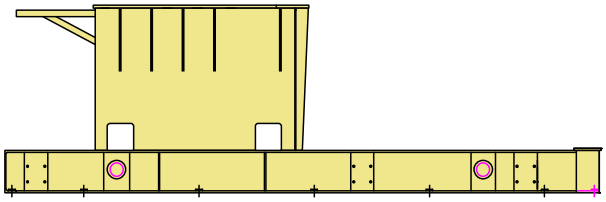
Pump Unit	L	H
H160-173-86	94.49 inches/ 2400 mm	47.2 inches / 1200 mm

In order to measure distance **L**, there is a counter-sunk measuring point located on the pump unit base, directly below the center bearing location. To properly align the base with the well-head, there is another center-line mark on the base between the mounting points of the front legs of the samson post.

When installing the pump unit for any foundation type, the foundation bolts of the pump unit must be properly tightened. Please see the following diagram with dimensions (mm):

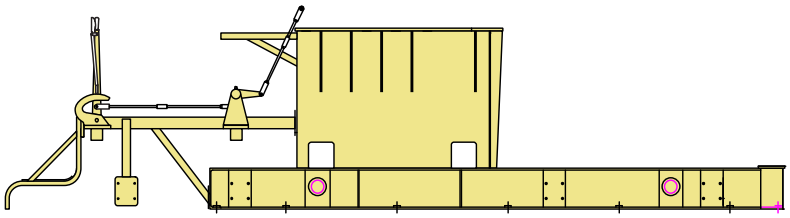


The foundation must be accurately level front to back and side to side. Further, metal spacing shims should be used as needed to ensure the pump unit base is level (the shims should be tack-welded into place after final level is confirmed). After adjusting level, fix the base on the foundation by loosely tightening foundation bolts—full torque will be applied after final adjustment of unit position with respect to the well-head.



6-3 Assemble Pump Unit

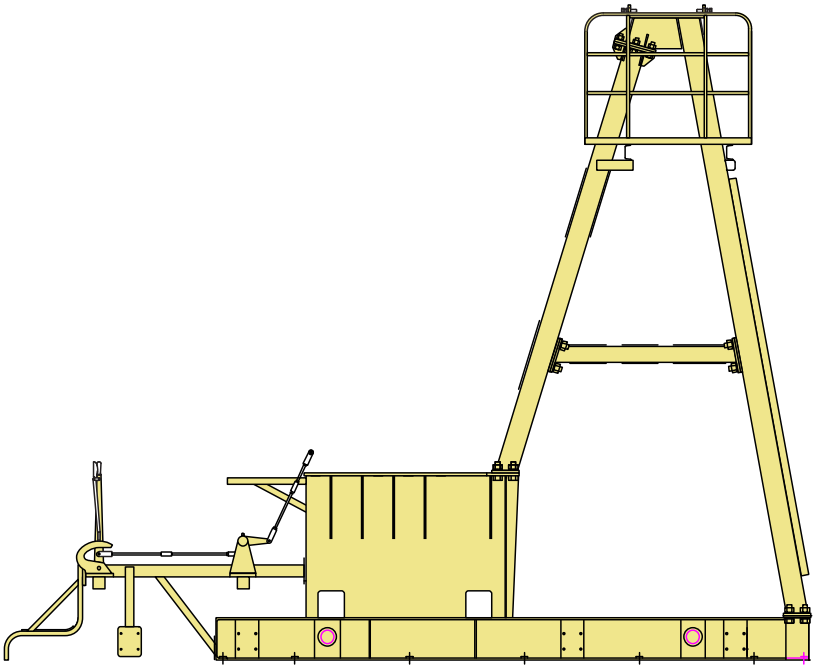
6-3-1 Prime mover support: Attach motor support frame to base. Then attach the brake handle and brake actuating linkage to the motor support frame. Properly torque all connecting bolts.



6-3-2 Samson post: First assemble the structure and then lift with a sling from the top of the samson post. The assembly will hang in a near vertical position for attachment to the base. Install the attaching bolts from the bottom so that the nuts will be on the top side. Tighten the bolts by hand only, with final torque to be applied after the center bearing plate is leveled.

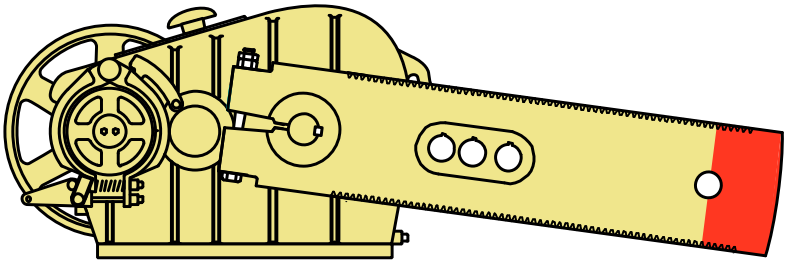
Use an accurate level to check that the center bearing seat plate is level in all directions. If needed, place metal spacing shims under the post legs (usually not necessary). After a level seat plate is ensured, properly torque the bolts attaching the samson post to the base.

The top center bearing seat plate on the samson post has a bolt hole, with a hollow core bolt installed. Pass the string of plumb bob through the center of the bolt to check if that reference point is directly over the mark on the base cross piece. The reference mark on the base is identified in the overhead base view found in Subsection 6-2 “Attach Base to Foundation.”



WARNING: Do not stand under any part of this shit during samson post assembly and installation. Gravity is a bitch. And you know what happened to Samson, right?

6-3-3 Cranks, crank pins, and gear reducer: The gear reducer is supplied with the two cranks already attached to its output shaft. Now the two install crank pins on the cranks. When facing the pump unit from the wellhead, the left-hand thread crank pin is installed on the left, and the right-hand thread crank pin is installed on the right. “Right-hand thread” means it is turned clockwise to tighten. “Left-hand thread” means it is turned counter-clockwise to tighten.



Note: It is important to clean the crank pins and bores—use a safe approved solvent. Also, be sure to apply a thin film of oil on the crank pins and inside the bores before installing.

WARNING: The reducer and crank assembly has heavy rotating weights (the cranks)—a danger that must be properly supported during movement.

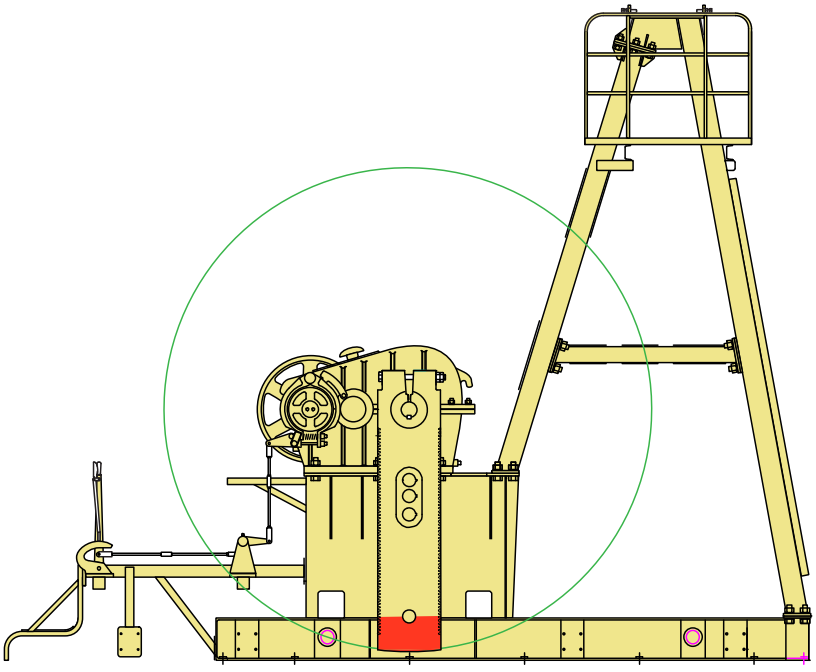
6-3-4 Gear reducer assembly: Place gear the reducer on its platform on the base, inserting the bolts from the bottom. Leave the hand tight so that the gear reducer can be shifted for alignment. Adjust the reducer on its platform so that the distance from the crankshaft to the samson post bolt holes on the base are the same on each side of the unit. After ensuring proper alignment, torque the bolts tight.

Note: Before allowing cranks to rotate (e.g. with lifting chains/cables), be sure to disengage and the brake stop pawl. After the cranks swing and stabilize at the 6 o'clock position, the brake can safely be connected.

Also Note: For various activities below, you will need to move and secure the cranks in another position. Attach chains/cables to both cranks with a long sling to minimize stress on the sling and cranks. After lifting the cranks to the desired position, set the brake shoes, set the stop pawl, and chain/cable the brake drum against rotation.

6-3-5 Brake actuating linkage: Connect the brake actuating rod to the brake on the gear reducer, adjusting so that the brake handle is in a position closer to the brake than its midpoint of possible travel. Then it can effectively engage the brake shoes without getting too close to the end of its travel. Tighten the lock nuts on the linkage to prevent loosening.

WARNING: The purpose of the brake is for stopping the pump at the point of crank rotation desired. It is NOT ADEQUATE for safely securing the pump for working around the cranks, horsehead, and other parts that may move. For such work, set the-brake stop pawl, chain/cable the brake drum against rotation, and/or otherwise secure the cranks against rotation.



6-3-6 Prime mover: Install the prime mover (typically an electric motor), adjusting its sheave location to align with the sheave of the gear reducer—each sheave being in the same plane. A taut string line can help align the two sheaves. Properly tighten a matched set of V-belts (never mix old and new belts). If the sheaves have extra grooves, those closest to the prime mover and gear reducer should be used for the V-belts.

Proper sheave alignment, V-belt selection, and V-belt tension are critical to trouble free service. While there are other quality options, we recommend Gates Corporation V-belts (Hi Power® and Predator®) and their instruction on use, including the ***"Heavy Duty V-Belt Drive Design Manual"*** (2010). For smaller diameter motor sheaves (6 to 9 inches diameter), consider notched Gates Tri-Power® V-belts. Gates also provides useful portable instruments for checking alignment of sheaves (laser beam) and tension of V-belts (vibration frequency).

When fewer pump strokes per minute are needed, one option is a smaller diameter motor sheave. However, smaller diameter sheaves tend to shorten V-belt life. Another option for fewer strokes per minute is to select a motor with rpm lower than 970 rpm as specified in this manual.

6-3-7 Belt cover: Install the belt cover, taking care that the cover has adequate clearance between it and the V-belts, motor sheave, and reducer sheave.

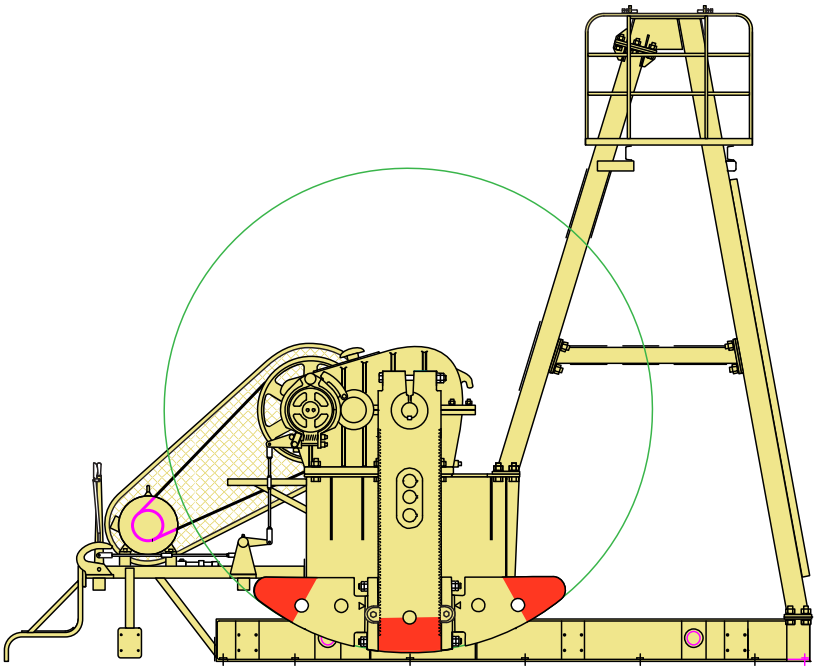
Note: Ensure compliance with all applicable safety regulations for guarding of belts and sheaves. API RP 11ER ***"Recommended Practice for Guarding of Pump Units"*** contains guidance you should be familiar with.

6-3-8 Power Supply: The power supply and control panel for the prime mover must be installed and tested according to manufacturer specifications. Generally, ensure that proper grounding, wire routing, and applicable electrical regulatory standards are met. Also, check that the resulting direction of revolution of the prime mover is correct.

WARNING: Contact with electricity at the pump unit can cause serious injury or death. Electrical power must be locked out prior to performing any work on the electric motor. All electrical work must be performed by a qualified electrician.

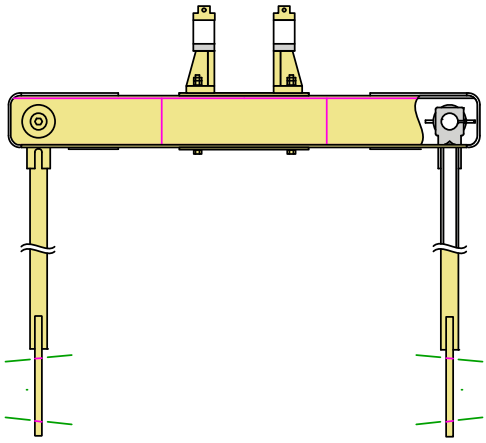
For safe grounding practices, refer to locally applicable regulations, the National Electrical Code, and the National Electrical Safety Code. Use the well casing as a convenient and effective ground. Connections and grounding conductors should be mechanically secure and placed to avoid disruption during well-service operations. Verify with ohmmeter continuity measurements between the well casing and each piece of grounded equipment (this measurement using locations on casing and equipment different than the grounding conductor connection). The resistance between grounded equipment and the casing should not exceed 1 ohm. The resistance between grounded equipment and another nearby ground should not exceed 5 ohms.

6-3-9 Crank weights: With the cranks in a vertical downward (6 o'clock) position, lift the weights by chains and position on the cranks. Primary attachment is with "T" bolts that slide into grooves on the cranks. Be sure to apply proper torque and a jam nut to the "T" bolts. Securing lugs with teeth to match those on the crank are placed to further prevent movement. Later the positions of the weights can be adjusted with the crank in a horizontal position (tilted slightly in the direction of movement)—remove the securing lug, loosen "T" bolts, then move the weight with the supplied special wrench, replace the securing lug, and re-tighten the "T" bolts.

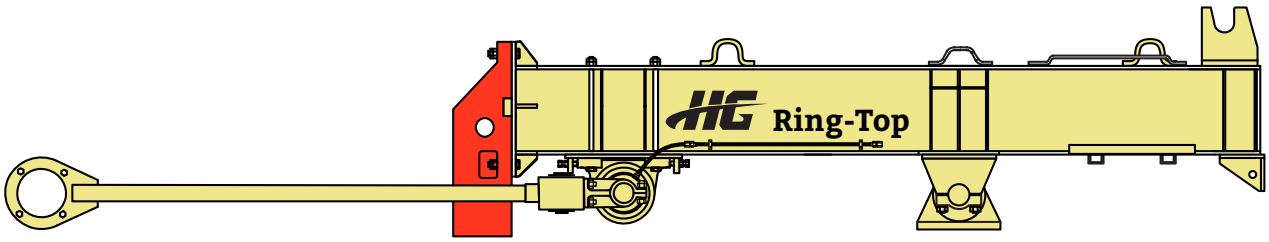


The position of the crank weights on the cranks are determined by the well load. Contact us for a recommendation abase on what you know about the well load. Also, see Subsection 9-3 "Adjust Balance" below for estimation and calculation methods.

6-3-10 Pitmans and equalizer beam assembly: Clean well every attachment point and pivoting surface. Apply Lithium grease (as specified in Section 8 "Lubrication" below) to pivot points on the upper ends of the pitmans. At the lower end of the pitmans, the larger opening is slightly tapered. This taper opens toward the centerline of the pump unit (the smaller diameter of that opening will face outward from the pump unit and cranks). Insert pitman attachment studs to secure the upper ends to the equalizer beam, securing them in place with bolted caps. Hammer the studs in with a rubber mallet or brass hammer to avoid damage to the studs. After assembling the guard plate, tighten the screw bolts using lock washers.



6-3-11 Walking beam assembly: The walking beam is delivered with the beam weight, equalizer bearing, and center bearing already attached. The bearings also have yolks mounted for engaging the equalizer beam and top of the samson post, respectively. Bolt the equalizer beam to the two yolks on the equalizer bearing shaft (four bolts), applying proper torque. Use lock washers and jam nuts to secure.



Steel tubing, rubber hose, fittings, and mounting clips are provided for remotely adding grease to the equalizer bearing. Part of the lubricating line for the equalizer bearing follows the walking beam, and part follows a samson post front leg. Install now the line section on the walking beam. However, before attaching to the equalizer bearing, completely fill the lubrication line with grease. Use a type of grease as specified in the Section 8 “Lubrication.”

WARNING: Do not stand under any elevated and unsupported parts of the assembly during this work. Sudden drops are always a possibility.

6-3-12 Pitman-equalizer-walking beam assembly: Lift the walking beam with a sling (horizontally) to gain access to the underside. Clean well the center bearing seat which will rest on the top of the samson post. Also clean the top plate of the samson post. Lift the pitman-equalizer-walking beam assembly by crane, keeping the walking beam horizontal. Position the center bearing over the top of the samson post. Bolt the samson post top-plate to the center bearing—hand tight. These bolts will be torqued after pitman alignment is checked.

6-3-13 Pitmans to crank pins: Slowly lower the equalizer end of the walking beam until the pitmans can be swung to attach to the crank pins. Ropes can guide the pitmans to avoid

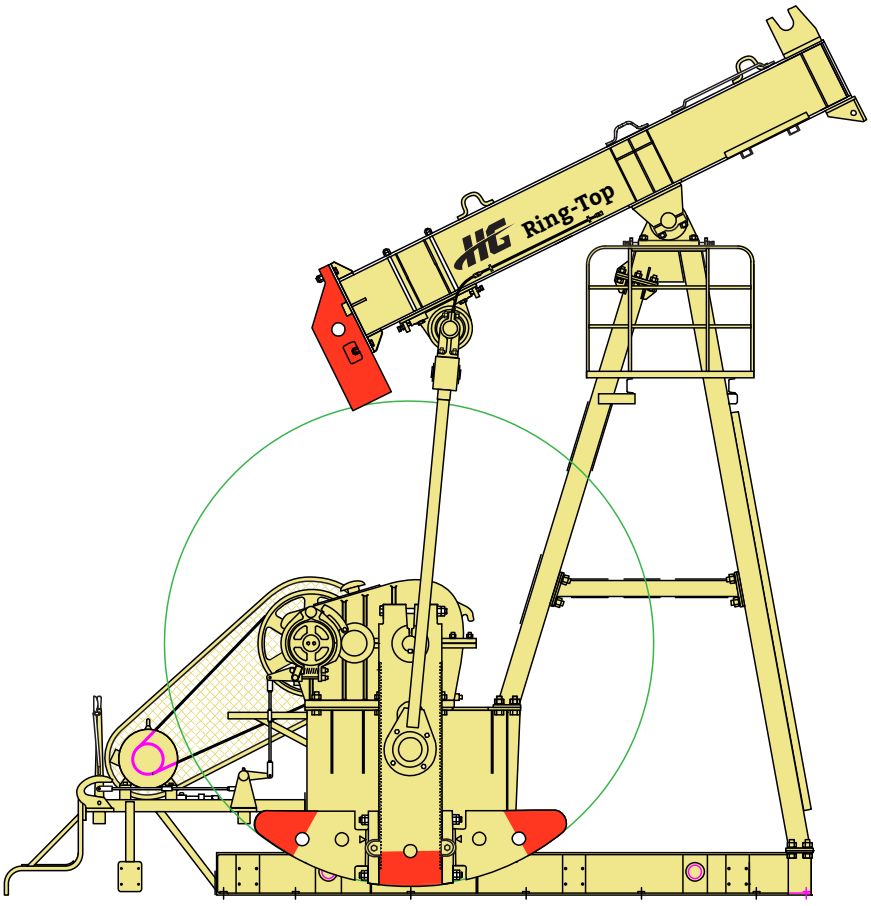
contact with any other parts of the pump. Ensure connection surfaces are clean. The pitman ends should fit smoothly on the crank pin connections.

Note: Do not use a hammer to position the lower ends of the pitmans on the crank pins—damage to the bearings could result.

If pitmans do not fit the crank pins squarely, the equalizer beam bolts can be loosened to get proper alignment—then retightened. Finally, align the bolt holes, place bolts, and properly torque the connecting bolts.

6-3-14 Pitman alignment: Accurately measure the gap between the reducer output shaft and the closest part of the pitmans on each side (cranks are now in the 6 o'clock position). The gaps should be identical within 1/8 of an inch. If not, slightly turn the walking beam on the samson post until alignment is proper. Now, fully torque the bolts connecting the center bearing yolk to the top of the samson post.

Note: Improper alignment of the pitmans to the crankshaft can cause stress to the pump unit and excessive component wear.



After Pitmans are attached—Cranks at the 6 o'clock position

6-3-15 Remote lubrication lines: Steel tubing, rubber hose, fittings, and mounting clips

are provided for remotely adding grease to the center bearing (in addition to the equalizer bearing mentioned above). Attach and connect the grease lines to the samson post. Before connecting to the equalizer bearing line on the walking beam, and directly to the center bearing, completely fill the lines with grease. Use the type of grease specified in Section 8 "Lubrication." Two bearing sets combine to form the center bearing, but only one lubricating point is required, as grease can flow between the two sets.

6-3-16 Horsehead assembly: At the top of the horsehead, remove the securing plate from the semi-circular seat for the wireline. Fold the wireline symmetrically along its length, place over the seat, and replace the securing plate and tighten the bolts. Then mount the carrier bar above the wireline terminals/lugs, pulling the wireline and ensuring that the carrier bar is level and parallel to the bottom of the horsehead. Two cotter pins in the carrier bar keep the wireline in position when the wireline is not under tension. Next attach the wireline bail, whose purpose is to keep the wireline in place should it be slack and movement takes place.

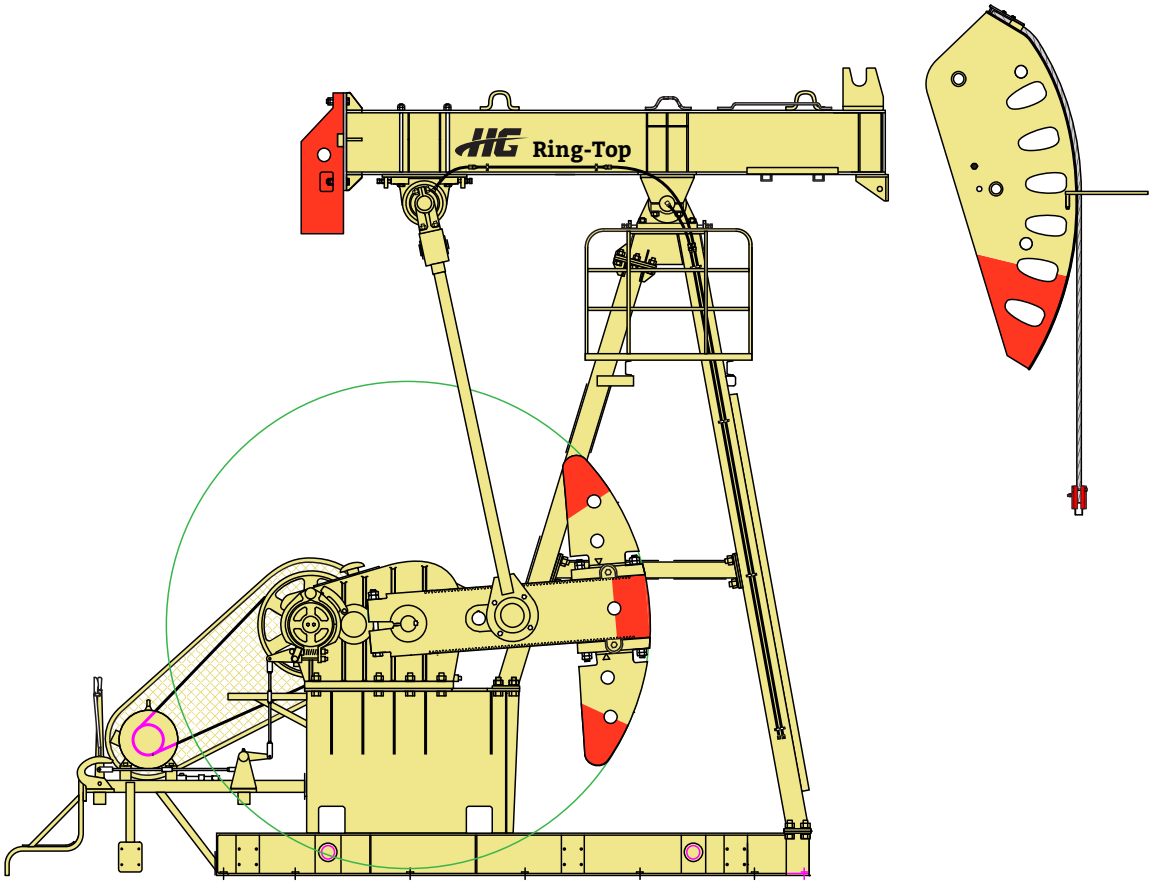
Finally, place the two adjustment bolts in the threaded bores on the sides of the horsehead, screwing in just enough so that the ends of the bolts are flush with the inside surface of the horsehead side plates. The adjustment bolts will be in position for tightening, but not susceptible to damage by hitting the walking beam from inside the horsehead during the mounting procedure.

Attach chains to the two cranks. Pull the chains taut with the crane, and check for equal support on each crank. Release the brake. Slowly raise the cranks until the beam is level. Reset the brake, engage the stop pawl, and chain the brake drum against clockwise rotation.

6-3-17 Mount horsehead: Sling the horsehead (with wireline) vertically by crane, and hang on the walking beam notch for the horsehead. The horsehead will pivot on the notch until the lower stop pipe rests against the stop on the walking beam. Insert the safety pins (secured with cotter pins). Check that the horsehead is aligned with the beam, and hand tighten the adjustment bolts.

WARNING: The safety pins must be kept in position, and adjusting bolts kept tight, except for when the horsehead is being adjusted, removed, or replaced.

Note: Comply with all applicable safety requirements for guarding the area of horsehead movement. API RP 11ER ***"Recommended Practice for Guarding of Pumping Units"*** contains guidance you should be familiar with. Ring-Top can supply horsehead/wellhead guards.



Walking Beam is level for mounting the Horsehead

6-3-18 Alignment with well head: Hold the carrier bar away from the polished rod with a rope, taking care to not be under the horsehead. Use a plumb bob from the center of the horsehead down along the polished rod. Ensure the distance from the string to the center of the polished rod is the same as the distance between the string and where the center of the wireline will travel. Additionally, after test initial running of the pump, use a level to check that the polished rod is vertical in various stroke positions

Make adjustments as needed. Some lateral adjustment can be made with adjusting bolts on the horsehead. The walking beam can be moved on the center bearing seat atop the samson post. Adjust the center bearing set screws in order that the center of Carrier bar aims toward the well head. Move the entire pump unit on its foundation if required.

Note: Pump alignment with the wellhead must accurate to within 1/16 of an inch.

After adjustment is complete, tighten the set screws and jam nuts at the top of the samson post. Also tighten the adjusting bolts on the horsehead. Finally, recheck the spacing of pitmans and reducer output shaft, as described above Subsection 6-3-14 “Pitman alignment.”

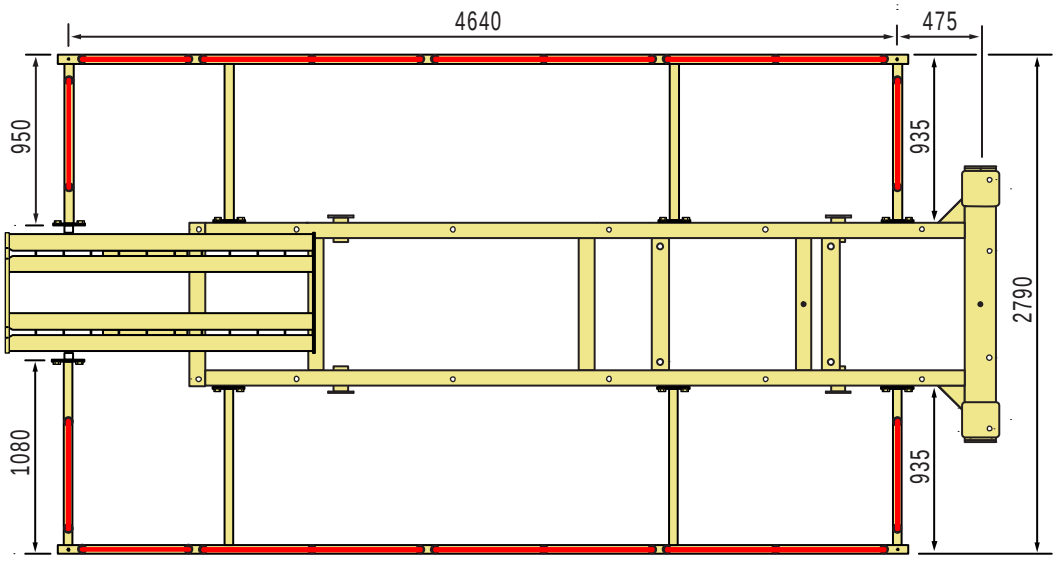
6-3-19 After final alignment: Support both cranks equally with chain/cable slings. Unchain the brake drum and disengage the brake drum stop pawl. Check to ensure the crank sweep area is clear, and then release the brake. Slowly lower the cranks (with the crane) to the bottom 6 o’clock position, and reset the brake.

Ensure that foundation bolts, and all other bolts on the pump unit, are tightened to proper torques.

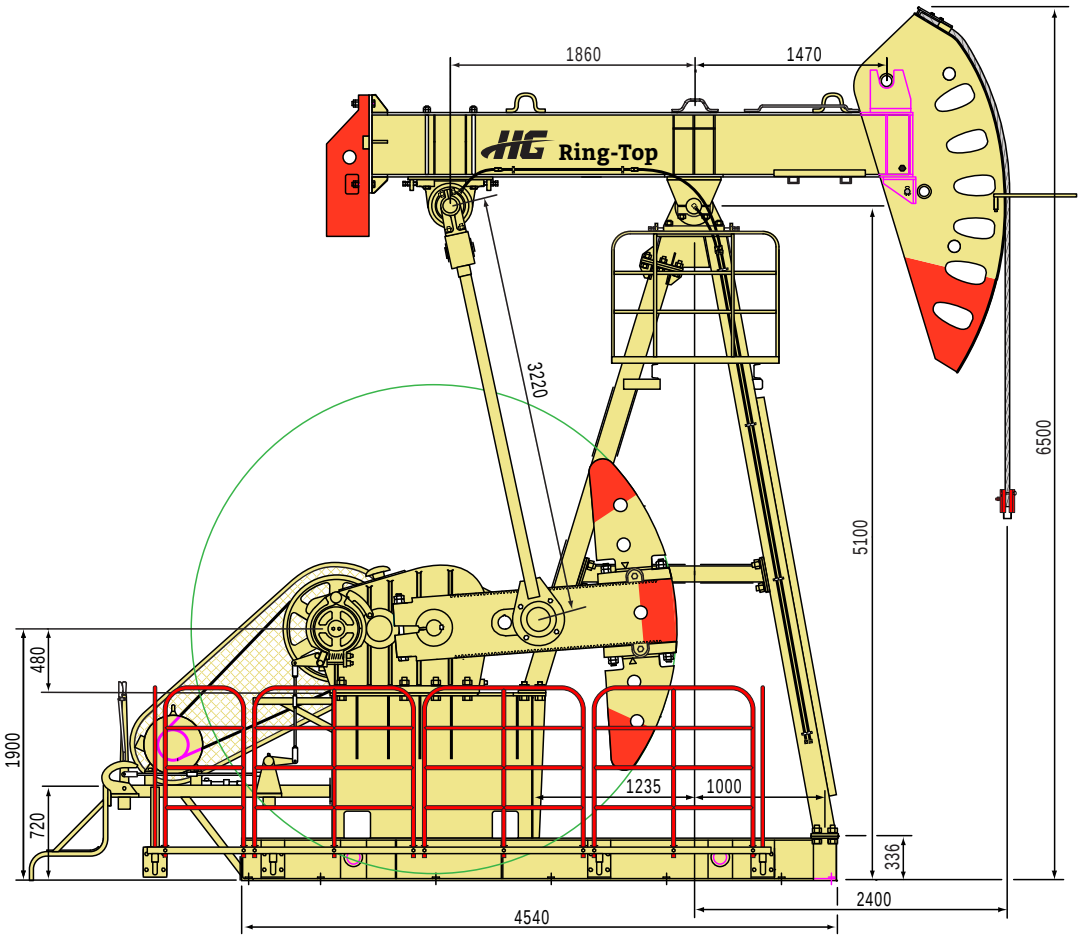
6-3-20 Install crank guards and safety signs: Before operating the pump, install the crank guard rails. While we have a standard design, your operating environment may require more extensive isolation, such as guards around the well heads, gated access, etc. Please know though that we are eager to help you meet any guard requirements, including custom designs.

WARNING: Stay clear of the crank sweep area and possible horsehead movement while installing the crank guards and wellhead guards.

Also, post appropriate warning signs for operators and bystanders. Again, we are ready to help meet this need, with standard and custom signage of a quality that will endure harsh outdoor environments.



Top view of crank guard rails (red) and support frame, with dimensions (mm).



Fully assembled Pump Unit, with dimensions (mm).

7 Operate the Pump Unit

Your Ring-Top beam pump was fully assembled and tested under rated loads at our factory. By following our installation and operating instructions, you can be confident of safe, long-lived, and properly performing pump unit.

WARNING: The integral ladder on the samson post is **NOT** to be used at any time while the unit is in operation.

This pump unit can operate with the rotation of the crank either clockwise or counterclockwise. The preferred direction is clockwise (viewing the pump from the side, with the wellhead on the right). If excessive wear or pitting of reducer gear teeth occurs, changing the direction of rotation can help since different contact surfaces of the gear teeth carry the load--prolonging the life of the reducer. A qualified electrician can reverse the rotation of three-phase electric motors by changing the motor's electrical connections.

7-1 Initial Lubrication

Add grease to the center bearing, equalizer bearing, and crank pin bearings until a small amount is seen coming out the weep holes for the bearings. Add grease slowly to avoid damaging the bearing seals. Use quality grease as specified in Section 8 "Lubrication" below.

Also, the wireline will require initial lubrication. Other bearings are lubricated before shipment. If you are separately purchasing a prime mover or other equipment to be used with the pump unit, follow the manufacturer's recommendations for lubricant as well as any other safety, maintenance and performance issues relating to those products.

CAUTION: When the equipment leaves our factory, the gear reducer does not contain lubricant. The internal reducer gears have only a light coating of oil to prevent rust. Before use, add gear oil as specified in Section 8 "Lubrication" below.

7-2 Safe Operation

Never operate pump units without all proper guards and warning signage in place. API RP 11ER ***"Recommended Practice for Guarding of Pumping Units"*** contains guidance you should be familiar with. As always, local, state, and federal regulations must be met, as well as applicable corporate safety standards.

Control the area, ensuring that only knowledgeable, trained personnel are participating in operational activities. Keep extraneous observers well away from potential harm.

7-3 Attach to Polished Rod Load

In Subsection 6-3-19 “After final alignment” we left the cranks in the 6 o'clock position, which is near to the top of the up stroke of the pump unit.

Pull the wireline and carrier bar away from the polished rod with a rope, chain, or cable. If the polished rod does not extend above the horsehead, add a polished rod extension. Slowly lift the polished rod with a crane from above the horsehead for the length of the stroke. Place a rod clamp just above the wellhead to ensure the polished rod does not fall.

WARNING: Always operate the crane and lifting hook from above the horsehead. Catching the bottom of the horsehead could cause it to fall off.

Mobile cranes require skill to operate. To avoid accidents, crane operators must understand the crane manual and proper operation.

Open the carrier bar and position it on the polished rod. Close and secure the carrier bar. Attach a rod clamp just above the carrier bar and tighten according to clamp manufacturer’s torque specifications. Release the pump brake and slowly lower the crane hook holding the polished rod until full load is on the pump unit. Reset the pump brake and remove the rod clamp from the wellhead.

WARNING: Keep hands clear of polished rod at the wellhead, since slipping rod clamps present a danger of crushed hands and fingers. Also during these procedures, be mindful of the danger of crank, horsehead, pitman, and other pump movement.

7-4 Initial Operation

Perform a check of the pump unit, ensuring that the unit is clear of tools, parts, and miscellany. The first revolution should be done as slowly as possible, closely observing clearance of the cranks and pitmans, including belt cover and crank guards. Adequate clearance between the carrier bar and the wellhead should also be confirmed.

WARNING: Rapid braking can damage the gears in the reducer. Apply a slow, steady engagement of the brake.

Slowly run the pump for a few minutes. Stop the pump with the horsehead at its highest point. To then secure the pump, fully set the brake, engage the brake stop pawl, Lockout/Tagout the prime mover, and attach a polished rod clamp at the wellhead to secure against movement. Now check all bolts on the unit to ensure they are properly tightened.

Note: Never allow the full weight of the well load to bear against the brake stop pawl. A crane may be required to free it.

Place the pump back into operation (reversing the prior steps to secure the pump) and run for thirty minutes. During this operation, be mindful of:

1. Sounds generated by the pump, such as the gear reducer and V-belts—skilled personnel can hear if the pump is clearly out of balance.
2. Solid attachment to the foundation.
3. Smooth steady movement, with no side-to-side swaying of pump mechanism, and completely vertical polished rod movement.
4. Proper alignment and movement of the wireline on the horsehead.
5. Good operation of the reducer brake, with brake handle stopping with movement to spare.

After stopping check for:

1. Proper V-belt tension.
2. Overheating components.
3. Oil leakage from the gear reducer.
4. Proper balance, if problems are apparent.

Now operate for about two hours and then check the balance of the pump according to procedures in Subsection 9-3 “Adjust Balance.”

Note: Bolt torque, V-belt tension, gear oil, and bearing lubrication must be rechecked after the first week of operation.

7-5 Well Service

Stop the cranks in the eight o'clock position (looking at the pump with the wellhead to the right). Set the brake and engage the brake stop pawl. Lockout/Tagout the prime mover. Attach a polished-rod clamp at the wellhead to hold it in position. Remove crank guards and attach chains to the cranks (at the bore near the end of the cranks) from a crane. Pull the chains taut, disengage the stop pawl and release the brake. Lift the cranks until the walking beam is level. Reapply the brake, engage the stop pawl, and chain the brake drum against rotation.

WARNING: Do not perform well service without first removing the horsehead. Always keep in mind that a stationary pump can suddenly start moving. Gravity is an ever present factor. Automatic start-stop controls on motors can be a risk to the unwary. Lockout/Tagout of energy sources and securing cranks against rotation are recurring critical safety steps.

Disconnect the carrier bar from the polished rod. Attach a rope or chain to the carrier bar so that a worker can hold it away from the polished rod. Attach a chain to the horsehead from the crane. Back out the adjustment bolts on each side of the horsehead until the bolt ends are flush with the inside of the side plates. Remove the two horsehead safety pins. Lift the horsehead from the beam and place it on the ground away from the work area.

Disengage the stop pawl and unchain the brake drum. Slowly release the brake to lower the cranks to the 6 o’clock position. Apply the brake again, engage the stop pawl, and chain the brake drum against rotation.

After well service is finished, again attach chains to the cranks from the crane. Unchain the drum, disengage the stop pawl, and release the brake. Lift the cranks until the beam is level. Apply the brake, engage the stop pawl, and chain the drum. Remove the chain from the cranks and attach to the horsehead. Mount the horsehead as described in Subsection 6-3-18 above.

8 Lubrication

When filling or adding gear oil to the reducer, ensure proper oil level (e.g. between the two lines on the sight glass). The lower part of the gear reducer can collect water from condensation, especially in climates which are humid and/or have pronounced fluctuating temperatures. Water in the reducer can emulsify with the oil, reduce its lubricating ability and contribute to corrosion. So, inspect and drain water regularly, adjusting how often according how much water is found. Oil sample (about a pint) analysis can help determine how often the gear oil should be replaced.

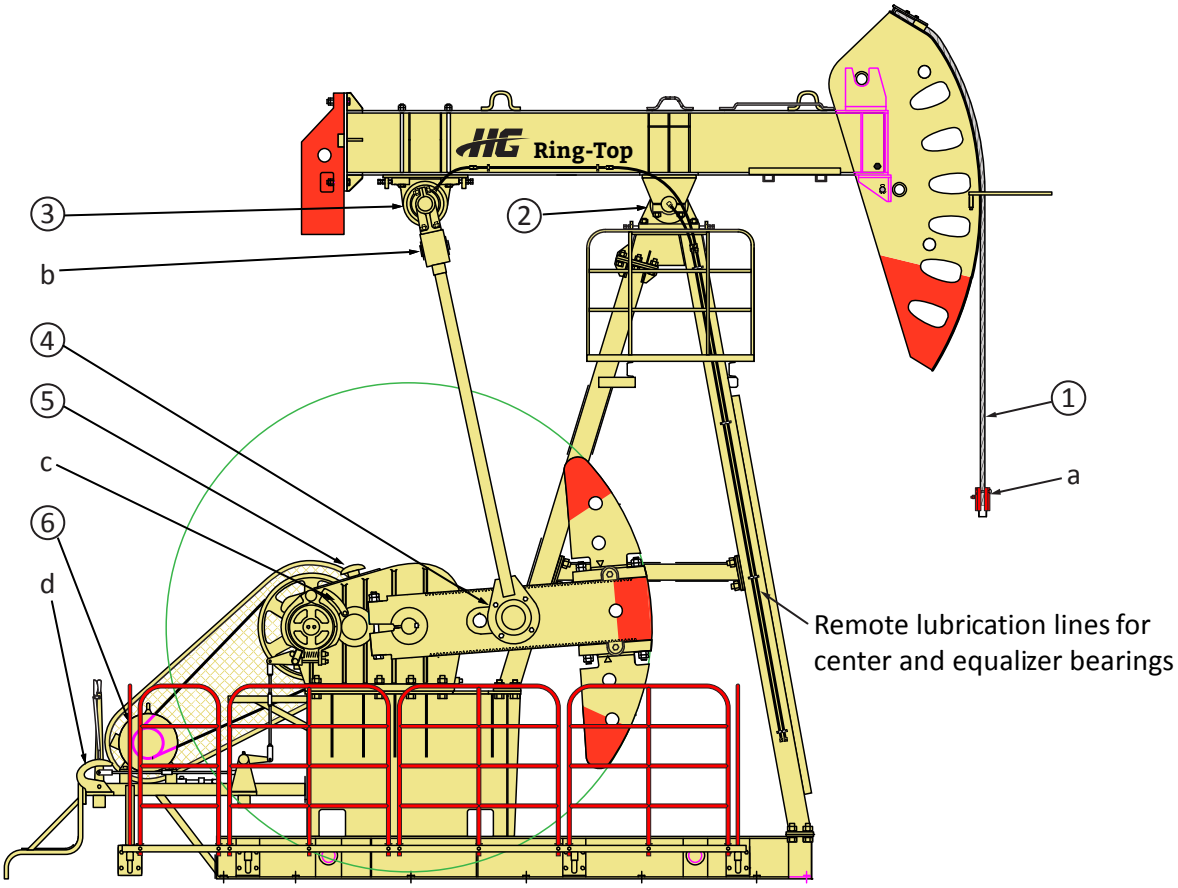
Note: The gear oil lubrication recommendations in this manual are only general guide. Your local lubricant supplier will be familiar with local conditions and can give more specific advice. Also, you should be familiar with the detailed guidance in API's RP 11G ***"Recommended practice for the installation and lubrication of pumping units."***

Use SAE motor oil only in emergencies. The emulsifiers in motor oil will combine with moisture from the air to turn the oil cloudy, reduce its effectiveness, and generate sludge.

In some cases of intermittent operation, weather extremes, or difficult service access, synthetic gear oil may be a justifiable expense. The viscosity of synthetic gear oil is less sensitive to temperature changes.

When adding grease to the center and equalizer bearing, remote lubricating lines allow this work to be done from ground level. Add grease until excess starts to ooze out of a weep hole on the opposite side of the bearings. Add grease slowly to avoid damaging bearing seals. Do not confuse the grease coming out of the weep holes with leaking bearing seals.

In addition to points ① to ⑥ on the lubrication card, screws on carrier bar (a), pitman pin (b), brake stop pawl (c), brake handle axle (d), etc, should be regularly coated with lubricant in order to prevent rust and corrosion. Every six months should be adequate.



Lubrication Card

Points to Lubricate	Ambient Temperature	Lubricant Product		Interval		Liters
		Lubricant Specification		Inspect (add lube as needed)	Replace or Add	Replace
① Wire Line	Any	ISO 15 to ISO 100 Wire rope grease		Monthly (visual inspection)	6 mos. (Add)	N/A
② Center Bearing	10°F to 200°For	NLGI GC/LB #2 Lithium grease		Monthly (check for seal leakage)	6 mos. (Add).	1.0
	-40°F to 150°F	NLGI GC/LB #0 Lithium grease				
③ Equalizer Bearing	10°F to 200°F	NLGI GC/LB #2 Lithium grease		Monthly (check for seal leakage)	6 mos. (Add)	0.8
	-40°F to 150°F	NLGI GC/LB #0 Lithium grease				
④ Crank Pin Bearing	10°F to 200°F	NLGI GC/LB #2 Lithium grease		Monthly (check for seal leakage)	6 mos. (Add).	1.0
	-40°F to 150°F	NLGI GC/LB #0 Lithium grease				
⑤ Gear Reducer	0°F to 200°F	AGMA 5 EP (ISO VG220)	Extreme-pressure premium industrial gear oil	Monthly (check gear oil level)	18 mos. (Replace)	105
	-30°F to 200°F	AGMA 4 EP (ISO VG150)				
⑥ Motor Bearing	10°F to 200°F	Follow motor's user manual.		Follow motor's user manual.		
	-40°F to 150°F					

9 Adjustment

Below find discussion and equations for making various adjustments to the pump unit. Please don't hesitate to consult with us on their use. In some cases modified equations may be needed to meet special circumstances. We enjoy the challenges of solving problems related to the use of beam pumps, and are more than glad to review your work or even do the calculations for you with the data you provide.

9-1 Adjust Stroke Length

The length of stroke can be varied by changing which of three different crank pin mounting points on the crank are used. Begin by stopping the cranks at the 2 o'clock position (looking at the pump with the wellhead on the right). Set the brake and engage the brake stop pawl. Attach a rod clamp to the polished rod above the wellhead to secure it against movement. Remove the crank guard rails. Attach chains/cables to the cranks, and with a crane pull them taught. Disengage the brake. Lift the cranks enough to remove the polished rod load from the wireline, and then reset the brake. Disconnect the carrier bar from the polished rod.

WARNING: Repositioning the crank pins presents many risks of injury. Plan the work carefully and employ knowledgeable personnel who are properly trained and equipped.

Holding the carrier bar away from the polished rod with a rope or chain, gradually release the brake and allow the cranks to move into the 4 o'clock position. Reapply the brake and engage the stop pawl. Lockout/Tagout power to the motor. Also chain the brake drum against clockwise rotation.

Now use come-a-longs or ratchet-boomers to restrain the walking beam against any movement after the crank pins are removed. Also support the pitmans so that they will not swing violently when the crank pins are removed from the cranks (the crank pins will remain attached to the pitmans). Proceed to remove the crank pins from the cranks, loosening both and checking for free movement before removing either one.

Note: Done properly, crank pin removable and reinstallation is rather demanding. If you lack the required experience or tools, please consult with us on this challenging procedure.

Swing the crank pins out and check the condition of pins and cranks bores. Excessive wear or the presence or rust may mean pins were loose. Keep the inside of the crank bores coated with good rust preventer.

Clean the crank pins and new bore positions, removing all paint, rust, and dirt. Use a safe solvent and emery cloth, but **NO** power grinders. Adjust beam supports to allow mating to the new crank bores. Use machinist's blue to confirm a good fit, and apply a thin coat of oil before final tightening in the desired crank bore.

Keeping the brake engaged and secured, remove the come-a-longs and/or ratchet-boomers. With the brake shoes fully tight against the brake drum, unchain the brake and disengage the stop pawl. Make any adjustments to crank weights required by the new configuration. Finally, attach the polished rod load to the pump unit as described above in Subsection 7-3 "Attach to Polished Rod Load," and return the pump unit to service.

9-2 Adjust Stroke Frequency

Stroke frequency depends on the diameter of sheaves on the prime mover, plus its rpm. For a 970 rpm electric motor, sheave diameters corresponding to different stroke frequencies are listed in the following table:

Pump Unit	Stroke RPM	Electric Motor sheave dia.	Reducer Input Shaft sheave dia.	Reducer Ratio
H160-173-86 (with 970 rpm electric motor)	6.4	6 inches	31.9 inches (810 mm)	28.506
	9.6	9 inches		
	11.7	11 inches		

To determine pump strokes per minute from a prime mover and sheave (pulley) sizes, the following equation applies:

$$\frac{pump\ strokes}{minute} = motor\ rpm\left(\frac{motor\ sheave\ dia}{reducer\ sheave\ dia}\right)\left(\frac{1}{reducer\ ratio}\right)$$

In this equation, the sheave diameters can be in either inches or mm, so long as the same units are used for both sheaves.

Also consider V-belt velocity with different sheaves and motor speeds. Values should be between 2000 and 5000 feet per second. Under 2000 ft/min leads to shorter belt life. Over 5000 ft/min requires dynamically balanced sheaves. The following equation applies, where velocity is ft/min and motor sheave diameter is inches:

$$velocity = \frac{\pi(motor\ sheave\ dia)(motor\ rpm)}{12}$$

A formula for calculating motor sheave diameter (inches) from reducer sheave diameter (inches), gear reducer ratio, stroke frequency, and motor rpm (revolutions per minute):

$$motor\ sheave\ dia = \frac{(reducer\ sheave\ dia)(reducer\ ratio)(strokes\ per\ min)}{motor\ rpm}$$

Next is a formula for calculating V-belt length (inches). Reducer sheave diameter (D), motor sheave diameter (d), and distance between the sheave centers (C) are all inches:

$$V\text{-}belt\ length = 2C + 1.57(D + d) + \frac{(D - d)^2}{4C}$$

For the above and many other calculations, we have developed spreadsheets which are available upon request.

9-3 Adjust Balance

Having run for two hours after installation, or when the well load is known to change, adjust the pump unit balance to ensure balanced operation.

Some people like to balance the load with a slightly "rod heavy" attitude (you know if you are one of those people). That is, when the unit stops pumping, it will naturally stop on the down stroke with the polished rod in a lowered position. This helps keep the rod free of dirt, extending the life of the rod and packing.

Below find some of the more useful and simple calculations that can be applied. However, we suggest you obtain and study more thorough analysis and recommendations to be found in the publication API RP 11L "**Design calculations for sucker rod pumping systems**."

The pump unit must balance the weight of the polished rod, plus provide force to move the polished rod and lift the fluid above the underground pump plunger. The ideal counterbalance effect (pounds) of the pump unit is a balance between the upstroke and downstroke polished rod loads. It can be estimated by the equation:

$$CBE_{ideal} = 1.06\left[0.5W_{fluid} + W_{rod}(1 - 0.127SG)\right]$$

Where:

CBE_{ideal} Ideal counterbalance effect, pounds. This is also an estimate of the average polished rod load, (PR) pounds.

W_{fluid} Weight of the fluid above the down hole pump plunger, pounds. This is calculated from density of the fluid (e.g. crude oil, water), depth of the well, diameter of the plunger, and diameter of the polished rod (see below).

W_{rod} Weight of the polished rod, pounds. This can be calculated from the density of the steel rod, the diameter of the polished rod, and the depth of the well.

SG Specific gravity of the fluid being pumped (e.g. crude oil, water), dimensionless. This is the ratio of the density of the fluid divided by the density of water at 4°C (1 gram per cc).

The above equation is only for typical steel polished rods with a specific gravity of about 7.85 compared to water. Let us know if you need an equation for polished rods made of fiberglass or other material. Also, friction load is not included, which can only be estimated from dynamometer analysis or experience with similar wells nearby. The term W_{fluid} in the above equation is calculated as follows:

$$W_{fluid} = 0.443SG\left(L_{well}A_{plunger} - 0.294W_{rod}\right)$$

Where:

L_{well} Depth of the well, feet.

$A_{plunger}$ Area of the plunger, square inches.

The heavier the rod string, the farther out on the crank the crank weights must be (but you know that). Once the CBE_{ideal} is known, the position of the crank weights can be determined. The "API geometry analysis" in Subsection 9-3-3 below provides detailed analysis, but we can

more simply estimate the crank weight positions with the following equation:

$$CBE_{ideal} = B_{struct} + W_{cwts}\left(\frac{R_{cwts}}{R_{pins}}\right)\left(\frac{L_{equal}}{L_{pol\ rod}}\right)$$

Where:

B_{struct} Unit structural imbalance, pounds (Section 4 "Specifications").

W_{cwts} Total weight of crank weights (Section 4 "Specifications"), pounds.

R_{cwts} Radius of crank shaft to crank weights ("▼" point on crank weights), inches.

R_{pin} Radius of crank pin bore in use (three options in Section 4 "Specifications"), inches.

L_{equal} Distance from the center bearing to the equalizer bearing (see illustration "Fully assembled Pump Unit, with dimensions" in Subsection 6-3-20 above), inches.

$L_{pol\ rod}$ Distance from the center bearing to the polished rod center line (see illustration "Fully assembled Pump Unit, with dimensions" in Subsection 6-3-20 above), inches.

Note: The radius and length numbers can be any units (e.g. inches or mm), so long as the two radii or two lengths are the same units. Also, if crank weights are located at different positions on the crank, the term after "$B +$" will need to be duplicated and added for additional position.

9-3-1 Electric Current method

A convenient technique is to connect an ammeter (or power current transducer assembly) to the motor's power lines. Be sure to keep ammeter jaws square to the power line being monitored. Take a number of max current draw readings, e.g. six pump stokes. Then calculate averages for up and down stroke max values separately. The fractional imbalance is determined by the following equation:

$$F_{imbal} = \left[\frac{I_{up} - I_{down}}{I_{up} + I_{down}}\right]$$

When the fractional imbalance is positive (upstroke current is relatively too large), the counterweight is too low, and the crank weights should be moved toward the ends of cranks (more crank weights may be required). When the fractional imbalance is negative (upstroke current is relatively too small), the counterweight is too much, and the crank weights should be moved toward the reducer output shaft.

CAUTION: If the pump unit is severely underbalanced, the torque exerted on the gear reducer by the weight of the polished rod can cause the motor to generate electricity. This generated electricity can appear to be power consumption indicated by an ammeter. Listening to the gearbox operation and observing dynamic V-belt tension can help identify this situation.

When an ammeter measurement indicates that a pump unit is out of balance, the following equation can be used to estimate how much to move the crank weights. A positive result indicates moving the crank weights toward the ends of the cranks. A negative result indicates moving the crank weights toward the crank shaft:

$$R_{adjust} = F_{imbal}\left[R_{cwts} + R_{pins}\left(\frac{B_{struct}}{W_{cwts}}\right)\left(\frac{L_{pol\,rod}}{L_{equal}}\right)\right]$$

Where:

R_{adjust} Distance to move crank weights from initial position at which electric current measurements were made, inches.

B_{struct} Unit structural imbalance, pounds.

W_{cwts} Total weight of crank weights, pounds.

R_{cwts} Radius of crank shaft to crank weights (initial position), inches.

R_{pins} Radius of crank pin bore in use (three possibilities), inches.

L_{equal} Distance from the center bearing to the equalizer bearing, inches.

$L_{pol\,rod}$ Distance from the center bearing to the polished rod center line, inches.

Note: If the crank weights are at different distances from the crank shaft, use an average value. This type of analysis and adjustment is rather approximate anyway.

9-3-2 Dynamometer Test

A dynamometer can be used to directly measure the load on the polished rod at the pump. This information can then be used to determine if the pump unit is properly balanced. Analysis on the data can further be used to determine the best stroke of the pump to use, whether the pump is optimally sized (not too big or too small), and if some type of intermittent or variable speed control is advisable.

First, a dynamometer is attached to the polished rod (there are a few different types—one type is placed between the carrier bar and the polished rod clamp). Then, force readings are collected throughout the pump cycle. This data is then used to compare up and down loadings for balance, plus calculate torque at the gear reducer output shaft (see formulae and data below).

Note: There are a number of automated testing and software tools which can analyze and suggest optimal pump operation, such as crank weight position adjustments. Analysis of the dynamometer data can also give clues to condition of the down hole pump.

9-3-3 API geometry analysis

To calculate torque at the gear reducer, we supply information specified by API Spec 11E ***"Specification for Pumping Units"*** in the table "Polished Rod Position and Torque Factors" below. Here we describe some of the calculations outlined in API Spec 11E. Please contact us for suggested calculation spreadsheets and other assistance for this analysis.

The net torque of exerted on the output shaft of the gear reducer by the cranks can be calculated by the formula:

$$T_n = TF(PR - B_{struct}) - Msin(\theta)$$

Where:

T_n Net reducer output shaft torque, pound-inches.

TF Torque factor, inches. The table below has values for various crank positions.

PR Polished rod load at θ, pounds (measured, calculated or estimated).

B_{struct} Unit structural imbalance, pounds. See table in Section 4 “Specifications” above.

M Maximum moment of crank counterbalance, pound-inches.

θ Position of crank, degrees. Clockwise from 12 o'clock (0°) with wellhead to the right.

The polished rod load (PR) can be measured with a dynamometer, calculated as described above, estimated from experience with similar wells, etc.

Maximum moment of crank counterbalance (M) can be calculated by the formula. This value can tell if the gear reducer is over-loaded on the up stroke:

$$M = TF_{at\ 90°}(CBE_{at\ 90°} - B_{struct})$$

Where:

CBE Net counterbalance effect, pounds. This value is determined by the weight/position of crank weights, cranks, crank pins, and also structural imbalance (includes beam balance weight). This is the downward force required at the polished rod to hold the beam without moving (and with no energy from the prime mover). This value is indicates how good the pump balance counterbalance matches the polished rod load. $CBE_{at\ 90°}$ can be calculated as follows:

$$T_{cranks} = \left(2R_{cg}W_{crank}\right) + \left(2R_{pins}W_{pin}\right)$$

$$T_{cranks\ \&\ crank\ wts} = (nR_{cwts}W_{cwt}) + T_{cranks}$$

$$CBE_{at\ 90°} = \left(\frac{T_{cranks\ \&\ cwts}}{TF_{at\ 90°}}\right) + B_{struct}$$

Where:

n Number of crank weights.

B_{struct} Unit structural imbalance, pounds (Section 4 “Specifications”).

R_{cg} Radius of crank center of gravity (Section 4 “Specifications”), inches.

R_{pin} Radius of crank pin bore in use (three options in Section 4 “Specifications”), inches.

R_{cwts} Radius of crank shaft to crank weights ("▼" point on crank weights), inches.

W_{crank} Weight of each crank (Section 4 “Specifications”), pounds.

W_{cwt} Weight of each crank weight (Section 4 “Specifications”), pounds.

W_{pin} Weight of each crank pin (Section 4 “Specifications”), pounds.

T_{cranks} Torque from the cranks and crank pins, pound-inches.

$T_{cranks\ \&\ cwts}$ Torque from the cranks, crank pins, and crank weights, pound-inches.

Try different values of $R_{crank\ wts}$ in the above formulae until a desired level of counterbalance effect, CBE, is obtained (this is where spreadsheets are handy). If crank weights are being used at more than one radius, the second equation must be expanded, duplicating the term $(nR_{cwts}W_{cwt})$ for each different value used for $R_{crank\ wts}$.

H160-173-86 Polished Rod Position and Torque Factors						
Stroke (inches)	86	66	55	86	66	55
Crank Position	Polished rod position			Torque Factor, TF (meters)		
0°	0.000	0.000	0.000	-0.049	-0.028	-0.016
15°	0.016	0.017	0.017	0.307	0.248	0.199
30°	0.073	0.073	0.072	0.636	0.502	0.396
45°	0.166	0.163	0.159	0.884	0.699	0.552
60°	0.281	0.276	0.271	1.021	0.817	0.653
75°	0.407	0.401	0.395	1.052	0.859	0.697
90°	0.531	0.527	0.523	1.009	0.838	0.689
105°	0.647	0.647	0.645	0.920	0.773	0.642
120°	0.751	0.755	0.756	0.806	0.679	0.565
135°	0.840	0.847	0.851	0.676	0.563	0.465
150°	0.913	0.921	0.925	0.528	0.426	0.345
165°	0.966	0.972	0.976	0.352	0.264	0.204
180°	0.996	0.998	0.999	0.135	0.076	0.045
195°	0.996	0.994	0.992	-0.131	-0.137	-0.127
210°	0.963	0.957	0.952	-0.425	-0.360	-0.301
225°	0.895	0.888	0.882	-0.701	-0.566	-0.461
240°	0.797	0.791	0.785	-0.912	-0.731	-0.591
255°	0.679	0.674	0.668	-1.043	-0.840	-0.679
270°	0.550	0.545	0.539	-1.095	-0.889	-0.720
285°	0.419	0.413	0.408	-1.080	-0.879	-0.712
300°	0.293	0.287	0.281	-1.001	-0.813	-0.657
315°	0.181	0.175	0.170	-0.860	-0.692	-0.555
330°	0.089	0.085	0.081	-0.652	-0.517	-0.409
345°	0.027	0.024	0.023	-0.379	-0.291	-0.225
360°	0.000	0.000	0.000	-0.049	-0.028	-0.016

Note: “Crank position” is degrees clockwise from the 12 o’clock (0°) position. “Polished rod position” is expressed as fraction of stroke above lowermost point.

10 Regular Maintenance

The following contains edited excerpts from the **"*Lease Pumper's Handbook*"** from The Commission on Marginally Producing Oil and Gas Wells of Oklahoma. We urge you to study that publication thoroughly—it is freely downloadable **here**. Another publication you should obtain, review, and apply is API's RP 11G, ***"Recommended Practice for Installation and Lubrication of Pumping Units."***

10-1 Daily Inspection

Your Ring-Top pump unit is very dependable and can operate for years between serious problems. Still, daily inspections can extend the life of the unit by locating problems before damage has occurred. When making any inspection, listen carefully to the sounds the pump unit makes—they can tell a lot about its condition. The inspection should also include a check for lubricating oil/grease leaks at reducer box and bearing seals. Do not confuse grease coming from weep holes for leaking bearing seals. Look on the unit and on the ground for loose objects, such as bolts, nuts, and washers.

10-2 Weekly Inspection

Perform the steps of the daily inspection. Walk completely around the pump unit and observe it in operation. Stop at good observation points to watch assembled parts for one complete revolution, looking for unusual motion and vibration, and listening for unusual noises.

A line of contrasting color should be painted across one face of the crank pin nut and for a few inches on the crank. Another line should be painted across the crank and reducer output shaft. These lines allow you to recognize any change in the alignment of the components, even if the crank is in motion. During the daily inspections afterward, note the smallest changes that may indicate that a nut or crank is loosening. If problems are found, stop the pump immediately for closer inspection and repair.

Examine the foundation, looking for soil erosion that could destabilize the foundation. Also look for damaging cracks and other evidence of incipient foundation failure.

Reminder: In the first week after installing the pump or changing the stroke length, the crank pin nuts should be closely checked for movement every day. Also, bolt torque, V-belt tension, gear oil, and bearing lubrication must be checked after the first week of operating a newly installed pump unit.

10-3 Monthly Inspection

Complete the steps of the weekly inspection. Check the fluid level in the gearbox if there is evidence of a leak. Observe wireline for fraying and adequate lubrication. Check for signs of rust on bolts, refreshing oil/grease coating as needed. Lubricate worn/leaking center, equalizer, and crank pin bearings.

Reminder: Be alert for changes in well conditions that require balance of the pump unit to be adjusted.

10-4 Quarterly Inspection

Complete the steps of monthly inspection.

WARNING: Before making adjustments or repairs to the brake or V-belts, stop the pump with the crank in the 6 o'clock position. Lockout/Tagout all energy sources. Clamp the polished rod at the wellhead. Engage the brake stop pawl. Immobilize the equalizer by chaining or otherwise anchoring it to the base.

Inspect the lining of brake shoes for wear and clearance adjustment. The brake shoes should just clear the drum when the brake is fully disengaged. When the brake handle is fully engaged, there should be several notches of travel left. Ensure the brake rods are straight. Make adjustments and repairs as needed.

Inspect the brake drum for cracks and chipping, especially around the hub and key area. Ensure the brake drum key is properly in place and tight. Check the brake stop pawl notches to see if any are chipped, cracked, or broken. Replace the drum if these problems arise.

For long V-belt life, check belt alignment and tension. Inspect the sheaves for wear and damage. See the previously mentioned ***"Heavy Duty V-Belt Drive Design Manual"*** from the Gates Corporation for troubleshooting advice.

Check lubricant in the prime mover as specified by manufacturer.

10-5 Six Month Inspection

Complete the steps of the quarterly inspection. The six month inspection is especially important.

Part of the visual inspection is performed with the pump unit in motion, and part of it is performed with the unit shut down and the brake lever set. Look for smooth operation with no lateral motion from the pump unit centerline. Check that the polished rod is moving vertically at all points in the pump stroke. Check that spacing between the pitmans and the crank shaft is the same for each crank.

Add lubricating grease to the center, equalizer, upper pitman, and crank pin bearings until a small amount is seen coming through the provided weep holes. Pump the grease slowly to avoid damaging bearing seals.

Inspect all bolts to find if they are rust-free and tight. Properly torque any bolts that are loose. Loose bolts are a major cause of pump unit failures. Apply a light coating of oil on all nuts and bolts to prevent rust.

For pump units which have experienced severe operating conditions, or are many years old, the six month inspection interval needs to be shortened to every five months, and then four

months, and then three months. With some older worn units, lubrication may be necessary monthly, with special maintenance attention in between.

Pitman arm and gearbox problems:

Two of the most damaging situations that may occur to the pump unit are a pitman coming loose and the stripping of gear teeth in the gearbox.

When the stroke length of a pump unit is changed, extreme care should be given to correctly clean, lubricate, key, and tighten the wrist pin on the crank pin bearing. If the nut should work loose and come off, the bore in the crank will be damaged, the walking beam twisted, and the wrist pin destroyed.

When checking the oil level in the gearbox, pay special attention for the presence of metal flakes in the oil. Small samples can be obtained from the lower petcock or plug. By wiping the oil on a clean cloth, any metal cuttings can usually be seen. When metal cuttings are detected, the cover should be removed, the gearbox flushed out and cleaned, problems corrected, and new oil added.

Periodically, but at least once per year, the gearbox cover should be removed and the interior closely examined with a flashlight. Inspect gear teeth for abnormal wear. Lubrication troughs should be checked to ensure that all of the bearings are receiving a sufficient amount of oil and that the oil level is high enough to engage the oil dippers and gears. The oil should be changed and the filter cleaned on a periodic basis. Gearboxes can also collect water and sludge that should be removed periodically for maximum bearing and gear life.

Gear Reducer Oil Replacement

As described in Section 8 “Lubrication,” typically gear reducer oil should be replaced every 18 months. However, many situations are not typical. Your local lubricant supplier, plus your own experience and practice in the area, will determine more precisely how often this important step should take place. Laboratory tests of oil samples are extremely helpful in determining an appropriate time for gear oil replacement.

Electrical Grounding

Recheck the effectiveness of grounding specified in Subsection 6-3-8 “Power Supply.” Verify with ohmmeter continuity measurements between the well casing and each piece of grounded equipment (this measurement using locations on casing and equipment different than the grounding conductor connection). The resistance between grounded equipment and the casing should not exceed 1 ohm. The resistance between grounded equipment and another nearby ground should not exceed 5 ohms.

11 Common Problems and Solutions

Problem	Symptoms	Causes	Solutions
Unstable operation	Samson post swaying, base and/or samson post vibrating, abnormal noise of motor.	1. Faulty foundation integrity 2. Loose connection between base and anchor bolts 3. Loose connection between base and samson post 4. Misalignment of horsehead and wellhead 5. Polished rod overload 6. Pump unit imbalance	1. Ensure foundation meets drawing specifications 2. Repair concrete at loose anchor points 3. Add metal spacers to ensure good fit between base and foundation 4. Properly align unit with wellhead 5. Adjust working condition according to this manual 6. Adjust balance of unit 7. Clean solids from well
Loosening and axial movement of crank pin	Alignment marks show movement, irregular noise	1. Lock nuts coming loose 2. Dirt in the crank-pin bores 3. Worn taper surface of crank-pin	1. Secure and tighten nuts 2. Clean the crank-pin bores 3. Replace the crank-pin
Reducer gear box overheating, irregular noise	Oil temperature is over 140°F, irregular noise	1. Gear oil level is too low or high 2. Wrong or bad quality gear oil	1. Add or remove gear oil 2. Replace the gear oil according to lubrication recommendations
Abnormal reducing gear bearing function	Oil temperature is over 140°F, irregular noise	1. Friction at seals or bearing cap 2. Failed bearing 3. Wear of gear tooth surfaces—gear spacing is too large 4. Loose key-way of helical gear	1. Tighten bearing supports 2. Clean or replace the bearing 3. Adjust bearing gap 4. Repair key-way
Abnormal operation of motor	Motor overheating, burning smell, irregular noise	1. Unbalanced unit operation and/or overload 2. Improper rotation direction 3. Inadequate oil in motor 4. Faulty motor bearing	1. Ensure pump unit is balanced and motor is adequately sized 2. Reverse rotation direction 3. Add oil 4. Repair or replace motor
Oil leaking out of gear reducer	Oil leaking from bearing cap, case seam, or gear box	1. Too much oil in gear box 2. Bad connection of case seam 3. Loose plugs in check-bores	1. Ensure proper gear oil level 2. Tighten the case screws evenly. Clean the connection surface and apply sealant if required 3. Properly torque plugs in check-bores
Improper brake operation	Brake will not stop unit, engages when not desired, or makes irregular noise	1. Improper adjustment of brake shoes 2. Worn brake shoes 3. Worn brake drum 4. Dirty brake shoes, drum, or other brake components	1. Adjust gap between brake shoes and brake drum 2. Replace brake shoes 3. Replace brake drum 4. Clean brake shoes, drum, and other brake components
Abnormal horsehead operation	Irregular noise or movement at horsehead, wearing of steel rope against side plate of horse-head	1. Inadequate steel rope lubrication 2. Pump unit is not balanced 3. Center bearing out of alignment 4. Improper position of horsehead 5. Partially worn steel rope	1. Coat all of wireline surface with wire rope lubricant 2. Adjust the balance of unit 3. Adjust the position of center bearing on samson post or base of pump unit 4. Correct horsehead position on walk-beam 5. Replace worn steel rope
Reducer working surfaces damaged	Badly worn or pitted internal components	1. Overloaded gear reducer 2. Pump unit is not properly balanced 3. Gear oil does not meet specs 4. Excessive normal wear	1. Operate under recommended condition 2. Adjust unit balance 3. Replace gear oil 4. Repair or replace the gear reducer

Problem	Symptoms	Causes	Solutions
Pitman arm is deformed or broken	The arm is vibrating with abnormal noise	1. The crank pin bearing is failing/has seized 2. Damage from too great a degree of unbalance or other improper operation	1. Repair/replace crank pin bearing 2. Adjust the unit balance 3. Inspect and repair welds and components 4. Ensure proper pump size is being used
Connection between crank and gear reducer is damaged	Alignment marks show movement, periodic throbbing, perhaps violently	1. Broken keys and/or damaged key-way on shaft 2. The connection bolts on crank at the reducer output shaft is loose	1. Replace the keys or change the key-way location 2. Tighten the tail cap at crank

12 Replacement Parts

12-1 Seals and V-belts

Described below are parts of beam pumps which will require periodic replacement by users, perhaps every couple years. We provide these parts to customers as needed at reasonable cost.

Type H160-173-86	Crank Pin bearing seal HG4-338-66	Center bearing seal HG4-692-67	Equalizer bearing seal HG4-338-66	Reducer Input shaft seal HG4-692-67	Reducer Output shaft seal HG4-692-67	V-belts
Model	**J type Seal 90×115×16**	**Seal PD140×170×16**	**J type Seal 110×140×16**	**Seal FB80×110×10**	**Seal FB180×210×15**	**C type 177" outer circumference**
Quantity/set	**2**	**2**	**2**	**2**	**2**	**2**

12-2 Bearings

With proper maintenance, bearings typically last for the life of the unit. However, below are the specifications for various beam pump bearings.

Type H160-173-86	Crank Pin Bearing	Center Bearing	Equalizer Bearing	Reducer Input Shaft Bearing	Reducer Middle Bearing	Reducer Output Shaft Bearing
Model	22318CA	22228CA	22324CA	NU2316	NU2320	23136CA
Size	ϕ140xϕ300×102	ϕ150xϕ320×108	ϕ340xϕ160×114	_____	_____	_____
Quantity/set	2	2	1	2	2	2

13 Technical Documents included with Pump Unit

One copy each:

13-1 User's Manual

This user's manual was custom prepared for your pump unit. However, our enthusiastic support does not end with the preparation of this manual. Please contact us with any questions, comments, or suggestions about your pump unit installation and operations.

13-2 Product Certificate

Your product certificate . . .

13-3 Packing List

Your packing list . . .

13-4 Registration Card for Pump Unit

Please timely complete and return the included registration card. The brief information on the location and use of your pump unit can help us in getting appropriate updates to you.

14 Registration Card for this Beam Pump Unit

Dear users,

After purchasing and installing your pump unit, please fill this card carefully and post, fax, or email to our company for quality guarantee and technical services. The card has our official seal when shipped with the product. To fully receive our quality guarantee and technical support, send the card back with an official seal/signature within 2 months after installing your pump unit.

Pumping Unit Model		Serial Number	
Purchase Date		Identification Number of Well	
Location of Well		Local Surface Temperature Range at Well	
Well Depth		Fractional Imbalance	
Strokes per Minute		Prime Mover HP	
Polished Rod Load		Liquid quantity produced daily	
Person Completing this card		Date this card Completed	

Using company (official seal/signature): _____

Using company (full name): _____

Telephone: _____ Fax: _____ Email: _____

Send to:

Tianjin Ring-Top Petroleum Manufacturing Co., Ltd.
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